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RESEARCH ARTICLE

ONE-YEAR FOLLOW-UP OF EXERCISES IN CHILDREN WITH ALLERGIC ASTHMA

Viara Dimitrova[1], Penka Perenovska[2] and Assen Aleksiev[1]

1. Department of Physical Medicine and Rehabilitation, Medical University - Sofia, University Hospital Alexandrovska, Bulgaria.
2. Department of Pediatrics, Medical University - Sofia, University Hospital Alexandrovska, Bulgaria.

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Abstract

Aim:- To study the effect of exercises in childhood allergic asthma, and to reveal their optimal frequency, intensity, and duration, because of missing consensus about them.

Material and Methods:- 12 children (age 11.17 ± 2.69 years) with allergic asthma were followed for one year. At the beginning and the end of the year, they were treated for 10 days with low daily doses of inhaled corticosteroids and exercises (breathing retraining, respiratory muscle training, and musculoskeletal flexibility with posture/balance training). The children and their parents were instructed to continue the same exercises at home as frequently, intensely, and prolong as possible for one year. Standard spirometry was performed four times – at the beginning and the end of the two 10-day treatment courses. The results were recorded as percentages of the actual versus the predicted spirometric parameters. MANOVA with Bonferroni's multiple comparison post-hoc tests and Pearson's correlation with multiple regression post-hoc tests were used for the statistical analysis.

Results:- The spirometric parameters showed a significant improvement at the end of each 10-day treatment course versus at the beginning ($P<0.05$), as well as at the end of the year versus at the beginning ($P<0.05$). There was a significant correlation of the spirometric parameters versus the exercise frequency ($P<0.05$) and versus the exercise intensity ($P<0.05$), but not versus the exercise duration ($P>0.05$). The regression analysis revealed that with increasing the exercise intensity and frequency (at least once daily) the spirometric parameters are improving significantly ($P<0.05$).

Conclusion:- Exercises significantly improve the spirometric parameters in children with allergic asthma. The optimal exercise frequency is at least once daily with high intensity and short duration.

Introduction:-

Asthma affects about 300 million people worldwide, making it a serious global health and social problem [1-9]. It is the most common chronic disease in childhood, affecting 7.2% of children globally [1-11]. Its social significance increases with the constant elevation of the treatment costs [1-8,12]. Other socially significant factors are the temporary disability for the parents of the affected child and the frequent interruptions of the child's educational

Corresponding Author:- Assen Romanov Aleksiev
Address**:-** Department of Physical Medicine and Rehabilitation, Medical University - Sofia, University Hospital Alexandrovska, Bulgaria.

cycle [1-8,13]. The problem is deepening in the developing countries, as well as in families with low social status, where asthma patients are exposed to additional harmful factors and allergens [1,2,4,5,7,8,11,14-23]. In heavily industrialized areas, high air pollution is a leading factor in the initiation, triggering, exaggeration, and development of the symptoms [1,2,4,5,7,8,11,14-22,24,25].

There is no consensus about the rationale of exercises in children with asthma [1,2,4,5,7,26-35]. Controversies exist between the findings that exercises are associated with improved quality of life and cardiovascular fitness versus the fact that the symptoms could be triggered by exercises, walking, laughter, crying, and many other daily living activities [1,2,4,5,7,26,27,29,31-36]. Avoiding strenuous exercises seems to reduce exacerbations of exercise-induced bronchoconstriction [1,4,5,7,26,27,29,31,32,36]. However, exercise avoidance may lead to deconditioning, reduced exercise tolerance, easier fatigue, tiredness, lethargy, higher risk for obesity, increased stress, and increased susceptibility to exacerbations during minimal daily living activities [1,2,4,5,7,26,27,29,31-33,36]. Moreover, breakthrough exercise-related symptoms could be managed by warm-up exercises [1,4,5,7,26,27,29,31,32,36]. Exercise-induced bronchoconstriction may also be related to obesity, lack of fitness, or conditions like inducible laryngeal obstruction [4,35,37-40]. In addition, weight reduction combined with exercises improves better asthma control (lung function, health status, and reduced medication needs in obese children with asthma) versus weight reduction alone [4,38,39]. Moreover, training and sufficient warm-up exercises reduce the incidence and severity of exercise-induced bronchoconstriction [4,37,39,40]. An additional factor contributing to inadequate asthma control in adolescents is poor treatment adherence [41].

The aim of our study was to study the effect of exercises in childhood allergic asthma and to reveal their optimal frequency, intensity, and duration, because of missing consensus about them.

Materials and Methods:-

During the enrolment process within the pediatric clinic of a Medical University Hospital, 12 children (age 11.17 ± 2.69 years) with allergic asthma were assessed for eligibility. The eligibility criteria were:- age 6-15 years with more than one symptom (wheeze, breath shortness, "Heavy breathing", non-productive cough, chest tightness), variable expiratory airflow limitation (reduced FEV1, reduced FEV_1/FVC below 0.90, positive bronchodilator reversibility test – increased FEV_1 above 12% from predicted), sputum eosinophilic airway inflammation, anamnesis of allergic disease like eczema, allergic rhinitis, drug or food allergy, worsening of the symptoms at night or early morning, variability of the symptoms (in frequency, duration, and intensity), initiation/triggering or worsening of the symptoms by viral infections, allergic exposure, smoke, strong smells, contrast temperatures, physical or mental stress [2,4,35,39,40]. The exclusion criteria were: other chronic lung diseases, productive cough, chest pain, bleeding, breathe shortness associated with impaired neurological symptoms (including dizziness), severe infections, as well as a severe deficiency – cardiovascular, respiratory, hepatic, metabolic, or renal [2,4,35,39,40].

The enrolled 12 children were followed for one year. At the beginning and the end of the year they were treated for 10 days with low daily doses of inhaled corticosteroids [42-44] and exercises: breathing retraining (exercises manipulating the breathing pattern); respiratory muscle training (exercises increasing the strength and endurance of the respiratory muscles); musculoskeletal flexibility and posture/balance training (exercises increasing the flexibility of the thoracic cage and improving posture by correcting the muscle imbalance) [2,32,45-47]. The children and their parents were instructed to continue the same exercises at home as frequently, intensely, and prolong as possible for one year.

The 'Breathing retraining' was aiming to correct the abnormal breathing patterns by adopting a slower respiratory rate with longer expiration, reducing hyperventilation, using a diaphragmatic type of resting breathing (rather than abdominal or upper-chest one), and using nasal breathing (rather than oral one) [2,32,46]. It was performing 2 times daily with 3 sets of 10 repetitions with a pause of 2 minutes between each set [2,47]. The diaphragmatic inspiration was performing from functional residual capacity to maximum inspiratory lung volume with 2 consecutive breaks while maintaining a ratio of 2 to 1 breath [2,47].

The 'respiratory muscle training' was performing 2 times daily with 3 sets of 10 repetitions with a pause of 2 minutes between each set [2,47]. Each repetition included a maximal inspiration from residual volume to total lung capacity in sitting position [2,47]. The expiration was performing at the functional residual capacity in order to avoid hyperventilation [2,47]. There were intervals of 60 s between these respiratory maneuvers [2,47].

The 'musculoskeletal flexibility training' included chest expansions, alt back expansions, sidearm rises, arm circles, torso flexion, extension, lateral flexion, and rotation [2,32,46,47]. It was performing 2 times daily with 3 sets of 10 repetitions with a pause of 2 minutes between each set [2,32,46,47]. The musculoskeletal posture/balance training was performing 2 times daily with 3 sets of 10 repetitions with a pause of 2 minutes between each set [2,45]. It included correction of the posture and muscle imbalance by relaxation/stretching of the shortened static muscles (pectoral, scapular elevator, upper trapezoidal) and strengthening of the elongated/flabby muscles (lower trapezoidal, rhomboid, serratus anterior) [2,45].

Standard spirometry was performed four times – at the beginning and the end of the two 10-day treatment courses [8,48-51]. The best of 3 trials in each spirometric test was recorded [8,48-51]. For statistical comparability, the results were recorded as percentages of the actual versus the predicted spirometric parameters. For the statistical analysis was used MANOVA with Bonferroni's multiple comparisons post-hoc tests and Pearson's correlation with multiple regression post-hoc tests.

Results:-

The spirometric parameter "forced expiratory volume for one second calculated as a percentage of the actual versus the predicted value" ("FEV_1 % Act/Pred") improved significantly at the end of each 10-day treatment course versus at the beginning ($P<0.05$), as well as at the end of the year versus at the beginning ($P<0.05$) (**Figure 1:-**). These results were confirmed with a very high level of the calculated statistical power (0.9), at the standard level of alpha (0.05), passed normality test (0.0259), and passed equal variance test (0.2309).

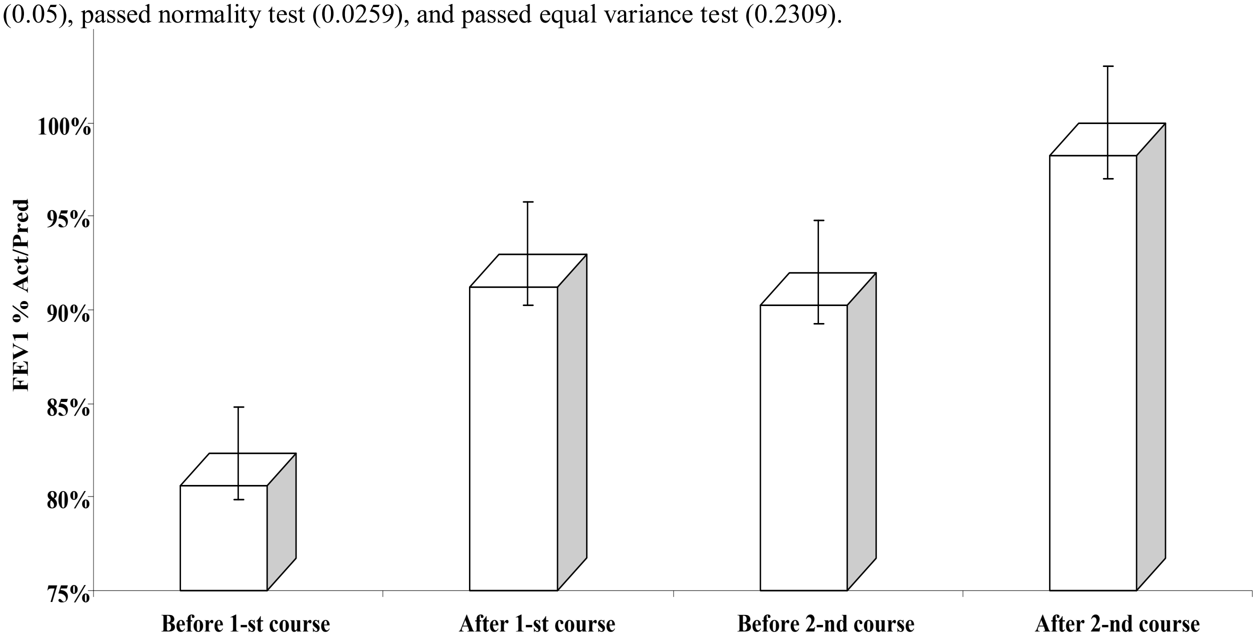

Figure 1:- Results from the spirometric parameter "Forced Expiratory Volume for one second calculated as a percentage of the Actual versus the Predicted value" ("FEV1 % Act/Pred"), recorded before and after the two 10-day treatment courses at the beginning and the end of the year.

The spirometric parameter "forced expiratory volume for one second calculated as a percentage of the actual versus the predicted value divided by the forced vital capacity calculated as a percentage of the actual versus the predicted value" (FEV_1/FVC % Act/Pred) improved significantly at the end of each 10-day treatment course versus at the beginning ($P<0.05$), as well as at the end of the year versus at the beginning ($P<0.05$). The MANOVA results from the other spirometric parameters were similar.

There was a significant correlation of the spirometric parameter "forced expiratory volume for one second calculated as a percentage of the actual versus the predicted value" ("FEV_1 % Act/Pred") versus the exercise frequency ($P<0.05$) and versus the exercise intensity ($P<0.05$), but not versus the exercise duration ($P>0.05$). The regression analysis revealed that with increasing the exercise intensity and frequency this spirometric parameter is improving significantly ($P<0.05$) according to the following formula:

$$FEV_1 \text{ \% Act/Pred} = 105{,}1 - (5{,}68 * \text{weekly exercise frequency}) - (2{,}99 * \text{exercise intensity})$$

Based on this real regression formula it was calculated a multiple linear regression mathematical model, including seven exercise frequencies (from one to seven times weekly) and three exercise intensities (minimal, average, and maximal). This mathematical model predicted that with increasing the exercise intensity and frequency the spirometric parameter "FEV_1 % Act/Pred" was improving significantly ($P<0.05$). According to this mathematical model, with increasing the exercise frequencies from one to seven times weekly, the spirometric parameter FEV_1 % Act/Pred was increasing correspondingly: from 56.37% to 90.45% if minimal exercise intensity was used; from 59.36% to 93.44% if average exercise intensity was used; and from 62.35% to 96.43% if maximal exercise intensity was used (**Figure 2:-).**

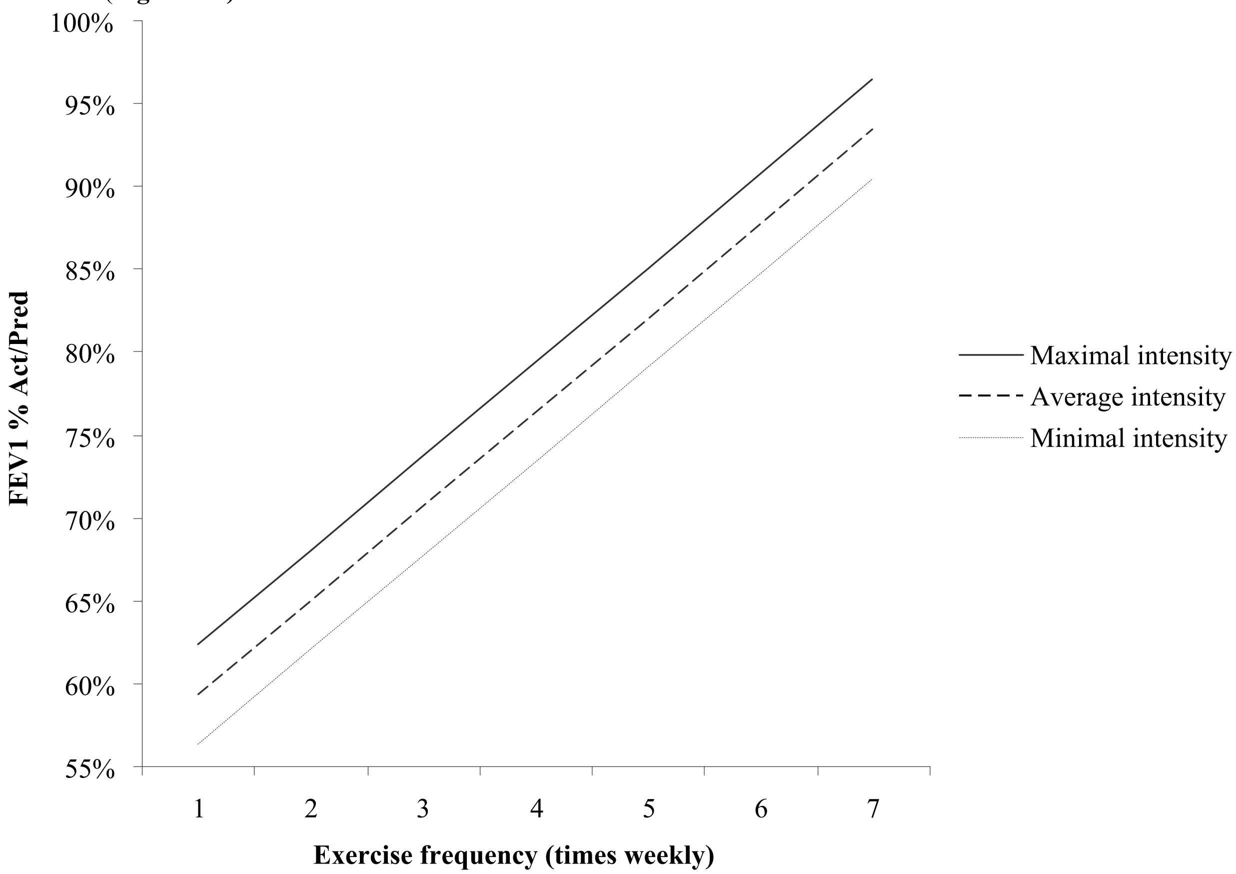

Figure 2:- A multiple linear regression mathematical model, including seven exercise frequencies (from one to seven times weekly) and three exercise intensities (minimal, average, and maximal), based on the following real regression formula: FEV1 % Act/Pred = 105,1 - (5,68 * weekly exercise frequency) - (2,99 * exercise intensity).

According to **Figure 2**, the statistical weight of the exercise frequency was twice higher than the one of the exercise intensity. On every increase of the exercise frequency with one time weekly, the spirometric parameter FEV_1 % Act/Pred was increasing by 5.68%. On every increase of the exercise intensity with one level, the spirometric parameter FEV_1 % Act/Pred was increasing by 2.99%.

There was a significant correlation of the spirometric parameter "forced expiratory volume for one second calculated as a percentage of the actual versus the predicted value divided by the forced vital capacity calculated as a percentage of the actual versus the predicted value" (FEV_1/FVC % Act/Pred) versus the exercise frequency ($P<0.05$) and versus the exercise intensity ($P<0.05$), but not versus the exercise duration ($P>0.05$). The correlation results from the other spirometric parameters were similar.

Discussion:-

From the results, it seems that the exercises had a statistically significant effect on childhood allergic asthma. These results were confirmed not only by the statistical significance of the P-value but also by the high power of the performed statistical test, the passed normality test, and the passed equal variance test. Therefore, it seems advisable for children with allergic asthma to use the most frequently prescribed exercises (breathing retraining, respiratory muscle training, and musculoskeletal flexibility with posture/balance training). This advice seems advisable for children at the age of 6-15 years with more than one symptom (wheeze, breath shortness, "Heavy breathing", non-productive cough, chest tightness), variable expiratory airflow limitation (reduced FEV_1, reduced FEV_1/FVC below 0.90, positive bronchodilator reversibility test – increased FEV_1 above 12% from predicted), sputum eosinophilic airway inflammation, anamnesis of allergic disease like eczema, allergic rhinitis, drug or food allergy, worsening of the symptoms at night or early morning, variability of the symptoms (in frequency, duration, and intensity), initiation/triggering or worsening of the symptoms by viral infections, allergic exposure, smoke, strong smells, contrast temperatures, physical or mental stress.

The exercise frequency and intensity were important therapeutic and prophylactic parameters, because they correlated with the spirometric parameters, while the exercise duration – did not. The statistical weight of the exercise frequency was twice higher than the one of the exercise intensity. With increasing the exercise frequency more than seven times weekly, the spirometric parameters were increasing above 90%. The optimal exercise frequency was at least once daily with high intensity and short duration.

The lack of any exercise-related exaggeration, bronchoconstriction, or other adverse symptoms during the short-term 10-day follow-ups, could be a result of the pharmacotherapy. However, there was no long-term pharmacotherapy during the 1-year follow-up. Therefore, the exercises did not trigger any exaggeration in the long-term 1-year follow-up without pharmacotherapy protection.

Conclusion:-

Exercises significantly improve the spirometric parameters in children with allergic asthma. The optimal exercise frequency is at least once daily with high intensity and short duration.

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